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Multifractal energy exchange between gravity waves and turbulence in an upper tropospheric front

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Intermittent generation of strong turbulence measured by reconnaissance aircraft occurred in association with a wide spectrum of upward propagating gravity waves above the core of an upper level jet stream. The turbulence generation process could be described as an energy cascade process, initiated as gravity-inertia waves were produced in a region of diagnosed unbalanced upper-level frontogenesis near a tropopause fold. High resolution numerical weather prediction model forecasts produced bimodal waves with dominant wavelengths of 120-216 km and 1-20 km, the latter of which perturbed the atmosphere to create conditions conducive to turbulence generation. Cross spectral, wavelet transformation, and polarization analysis of the in situ aircraft data allowed unambiguous determination of the presence of the spectrum of gravity waves, reconstruction of the waves' evolving character, and identification of intermittent wave packets. Introduction of wavelet cross spectrum into the Stokes parameter theory shed light on how turbulence production was intimately related to increasing levels of polarization, only to be followed by sudden reduction of polarization as turbulence arose. Wavelet and structure function analysis indicated that episodes of high turbulent kinetic energy were the result of upscale feedback effects ("inverse energy cascade" processes linked to wave breaking). The bi-fractal nature of the gravity waves and turbulence suggest new approaches for parameterizing sub grid-scale effects caused by the interaction of waves and turbulence in numerical models.